

about $2\frac{3}{4}$ cm., on the right-hand side of this line AB, is somewhat lighter than the space between it and the border about 10 cm. on its left. I find by careful measurement that the line AB is, at its end next A, 101.0 mm. from the last-mentioned border, and at a quarter of its length below B is 100.3 mm. from the same border. Corresponding measurements by the same eye and hand on another print of the same primary photograph, in which the line AB is scarcely visible, gave for its distance from the border at the end next A, 101.1 mm. From these measurements, and from the appearance of the print accompanying this note, I am convinced that there is a real difference on the two sides of a sharp boundary line AB which, as I am informed by Lord Blythwood, corresponds to the boundary between two mirrors of speculum-metal which were placed together in his experiment.

He promises further experiments with pieces of lead placed on the speculum-metal mirror. He has already tried experiments with pieces of paper and pasteboard placed on it; they show nothing on the photograph.

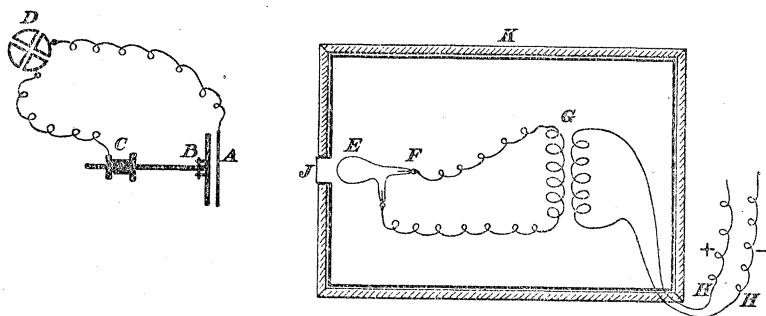
- V. "On the Effect of the Röntgen X Rays on the Contact Electricity of Metals." By JAMES R. ERSKINE MURRAY, B.Sc., 1851 Exhibition Scholar, Trinity College, Cambridge. Communicated by Professor J. J. THOMSON, F.R.S. Received March 3, 1896.

§ 1. The experiments described in this communication were made in the Cavendish Laboratory of the University of Cambridge, at Professor J. J. Thomson's suggestion, in order to find whether the contact potential of a pair of plates of different metals is in any way affected by the passage of the Röntgen "X" rays between the plates.

§ 2. The vacuum bulb and induction coil for the production of the rays were enclosed in a box lined with metal, so that the plates and the apparatus used in measuring their contact potential difference should be screened from any direct electrical disturbances. At one side of the box there was a circular hole of about 3 cm. in diameter. The vacuum bulb was placed just inside this hole, and directed so that the rays should stream out through it in a direction perpendicular to the side of the box. In some experiments this hole was closed by a tinfoil screen, which allowed a large proportion of the rays to pass out while shutting in ordinary electrical disturbances. The plates whose contact potential difference was to be measured were placed at a short distance outside the box, in such a position that the rays could fall on them.

2 A 2

§ 3. The diagram given below shows a plan of the principal parts of the apparatus, but omits the insulating supports and the subsidiary apparatus used in determining the contact potential by Lord Kelvin's null method. It is drawn roughly to scale, so as to show the relative dimensions and positions of the various parts.



- A. Tinfoil plate.
- B. Zinc plate, supported by a brass rod, which slides through the brass collar C.
- D. Quadrant electrometer.
- E. Vacuum tube.
- F. Negative electrode of tube.
- G. Induction coil.
- H, H. Wires connecting house battery to induction coil.
- J. Tinfoil screen—over the hole from which the rays issued—used in some experiments.
- K. Wooden box lined with sheet zinc.

§ 4. To measure their contact potential, I used the null method described by Lord Kelvin in his paper given to the British Association in 1880. I shall not describe this method in detail in the present communication, but may mention that the value of the contact potential is found by measuring the amount of the counter potential which has to be applied to the pair of plates to reduce the potential difference between their opposing surfaces to zero. The counter potential introduced to effect this annulment must obviously be equal and opposite to their contact potential difference.

Hence the numerical value of the latter is simply that of the applied counter potential, but is of opposite sign.

§ 5. The plates were of zinc and tinfoil, the latter being mounted on thin ebonite to keep it flat. They were placed parallel to one another at a small distance apart, so that the rays fell perpendicularly on the back of the tinfoil plate, passed through it and the air space between them, and were absorbed by the zinc. The tinfoil plate was insulated and connected to the insulated quadrants of a Kelvin quadrant electrometer. The zinc was uninsulated, and was connected to the unin-

sulated quadrants of the electrometer. This plate is movable in a direction perpendicular to its plane, and can thus be drawn away from the tinfoil. If there is any electric potential difference between the opposing surfaces of the two plates, further separation causes a change in it which, reacting on the electrometer, deflects it.

§ 6. When everything was in position, before starting the rays I measured the contact potential of the plates by the method mentioned above, and found it to be

$$+0.44 \text{ volt,}$$

the zinc being positive to the tinfoil. The rays were now turned on, so as to pass through the tinfoil plate on to the zinc. The contact potential, measured while the rays were passing, was about

$$+0.43 \text{ volt.}$$

But before the plates could be separated to see whether the counter potential applied had annulled the contact potential or not, the charge leaked away as if the insulation of the tinfoil plate were bad. Also I observed that when the plates were not in connexion with one another, but only with the electrometer, they seemed to act as though they were connected together by a bad conductor or an electrolyte.

§ 7. The X rays were now turned on so as to pass perpendicularly through the tinfoil plate on to the zinc. In a few minutes the deflection indicated

$$-0.50 \text{ volt.}$$

and remained steady there for several minutes. While in this condition I separated the plates. The deflection increased by a small amount, showing that the electrolytic power of the air while the rays are passing through it had somewhat more than counterbalanced the contact potential of the plates, and had established a slight difference of potential in the direction opposite to that which exists between the surfaces of the plates when connected metallically in air. This was confirmed by a measurement, made immediately after, by the null method, which gave

$$+0.44 \text{ volt}$$

for the potential difference between the plates; the rays not being on at the time.

§ 8. In the experiments described above, the rays had fallen perpendicularly on the plates, passing through the tinfoil (see diagram). I now placed them so that the rays should pass between them in a direction approximately parallel to their surfaces. On breaking the metallic connexion between the plates and turning on the rays the electrometer rose to

$$-0.39 \text{ volt,}$$

and remained steady there. Separating the plates produced no further deflection, which shows that the contact potential difference between the surfaces of the plates has been reduced to zero. This is confirmed by the measurement, made by the null method, of their contact potential, which is now

$$+0.39 \text{ volt.}$$

§ 9. In the above experiment the plates were at about one centimetre apart. I now increased the distance between them to two, then to five, and then to ten centimetres; but in spite of the fact that in the last case the rays must have passed almost entirely through the air between the plates without striking on their surfaces, the electrometer always crept up from zero to -0.39 volt in a minute or two, and remained almost steady at that value.

§ 10. In the above experiments there was no screen between the vacuum bulb and the ebonite back of the tinfoil plate. To make sure that none of the effects observed were due to ordinary electrical disturbances I now placed a piece of tinfoil, in connexion with the metal lining of the box containing bulb and coil, over the hole in the box from which the rays issued. With the plates parallel to the rays and at about one centimetre apart the electrometer rose, while the rays were on, from zero to -0.39 volt in two minutes and remained steady there. This shows that the effects above described are due to the new rays, which can pass with ease through tinfoil, and not to the more ordinary forms of electric radiation.

§ 11. In order to find whether these phenomena were strictly comparable with the results which Lord Kelvin had got many years ago by connecting the plates through an electrolyte, I made several experiments in which connexion was made by a drop of acidulated water.

Before doing so, however, I measured their potential difference by the null method and found it to be

$$+0.57 \text{ volt.}$$

This variation from previous determinations is due no doubt to the influence of the atmosphere in tarnishing the plates. It is much less than the changes, due to that cause, which I have often found in other experiments on contact electricity. I now joined the plates by a drop of acidulated water while they were in connexion with the electrometer only. The deflection at once rose from zero to

$$-0.54 \text{ volt.}$$

I now separated the plates, but this did not cause any notable change in the deflection, though it tended slightly in the direction which indicated that the contact potential of the plates had not been

quite balanced by the electrolytic action. This is confirmed by the difference between 0.57 and -0.54 given above. After a short while the deflection fell to

-0.48 volt,

which is nearly the value found previously for untarnished zinc and tinfoil in air, showing that the acidulated water has, in all probability, removed the tarnish, and is now balancing the contact potential between clean surfaces of the metals. The water was now removed, and the contact potential measured by the null method as before. It is still

+0.57 volt,

for, of course, by far the greater part of the surfaces of the plates is still tarnished as before. In another experiment with a drop of acidulated water between the plates, I found that the contact potential was more than counter-balanced by the electrolytic action. This corresponds to the action of the rays mentioned in § 7.

§ 12. It now occurred to me, that perhaps the electrolytic connexion established between the plates when the rays were passing might be through the insulating supports of the tinfoil plate, and not through the air, as I had hitherto supposed. To test the truth of this idea, several variations were made in the arrangements, all with a view to place the insulators in such a position that the rays could not reach them. First, I placed a screen of sheet zinc, with a hole in the middle of it, between the tinfoil plate and the hole in the box, from which the rays issue, so that the rays from the negative electrode of the vacuum bulb could fall only on the tinfoil plate and not on its insulating supports. These, by the way, consisted of pieces of good red sealing-wax, and, under ordinary conditions, were excellent insulators. When the rays were started the electrometer moved from zero to a position which indicated a difference of potential as great as or greater than any which had been previously observed. This shows that the electrolytic connexion had not been at all affected by screening the solid insulators.

This experiment was repeated several times, and in every case the result was the same. Still further confirmation of the aerial nature of the connexion was obtained by a great alteration in the length and position of the insulating support. Instead of three short arches of sealing-wax, each made of one stick about 6 inches long, I used one tall one fully 12 inches high; one leg was attached to the wooden framework on which the uninsulated zinc plate was mounted, and the other, which was somewhat longer, held the tinfoil plate. The new insulator was thus one piece, about 24 inches long, of sealing-wax, with the greater part far removed from the rays, instead of six pieces each 3 inches long. A number of experiments were made with

this arrangement. In all of them the potential varied under the influence of the rays by an amount similar in direction and magnitude to that previously observed.

§ 13. I have observed that the activity of the vacuum bulb seems to determine, to some extent, the potential difference observed on the electrometer; that is to say, if the rays are very weak and unsteady (as judged by the fluorescence of the vacuum bulb) they do not make the air sufficiently electrolytic to counterbalance the contact potential difference between the surfaces of the plates. Thus, when the bulb is not fluorescing brightly and steadily, one gets results which are uncertain and perplexing. But these appear to give place in all cases to more definite values whenever the rays are strong and steady.

§ 14. The conclusions I have drawn from these experiments are that (1) the influence of the rays on the zinc and tinfoil plates does not cause any direct or sudden change in their contact potential, but that (2) the air through which the rays pass is temporarily converted into an electrolyte, and when in this condition forms a connexion between the plates which has the same properties as a drop of acidulated water, namely, it rapidly reduces the potential between the opposing surfaces of the plates to zero, and may even reverse it to a small extent.

It is interesting to note that this electrolytic property was found by Lord Kelvin ('Electrostatics and Magnetism,' Art. XXIII, §§ 412—414) to be possessed by the fumes from a burning spirit lamp. In both cases its cause is probably the same. It is, no doubt, due to a want of electrical equilibrium among, and a partial dissociation of, the molecules of the gas.

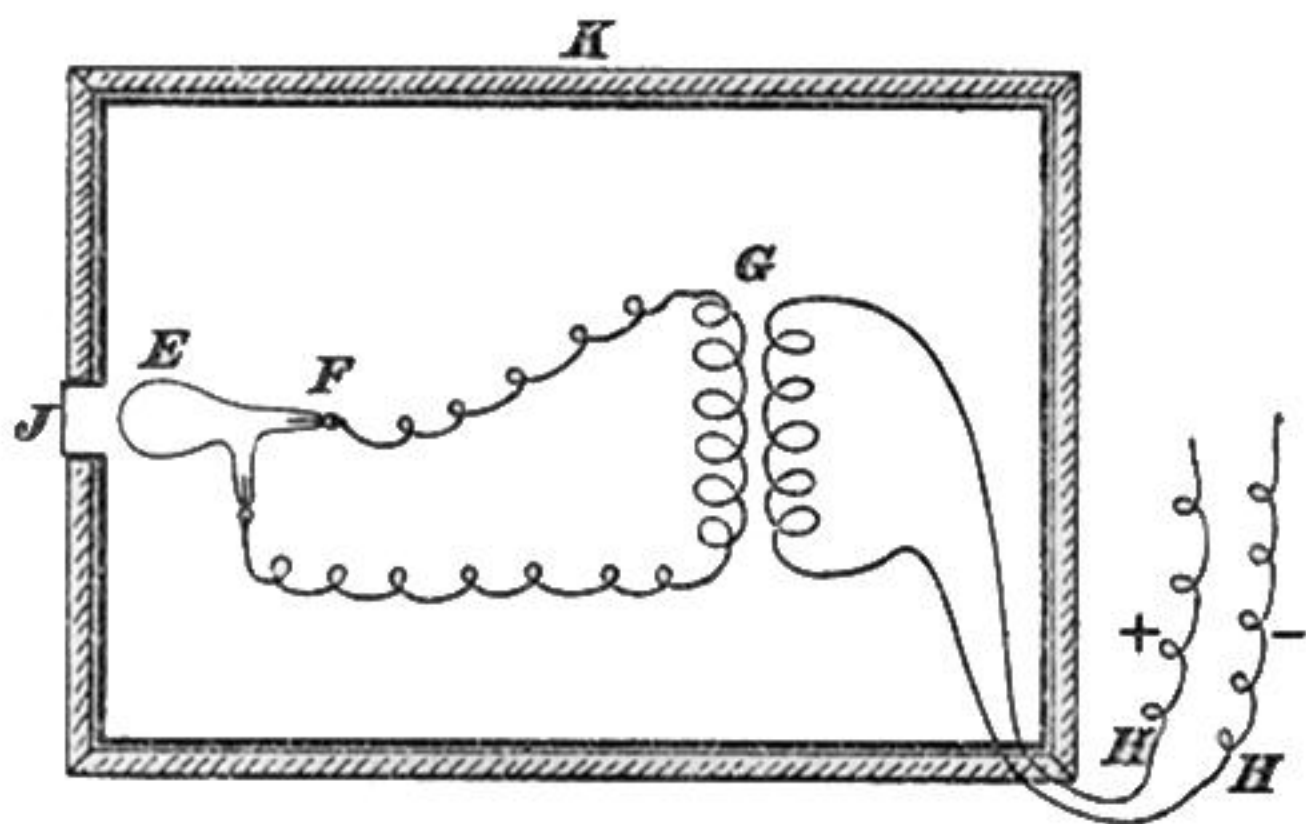
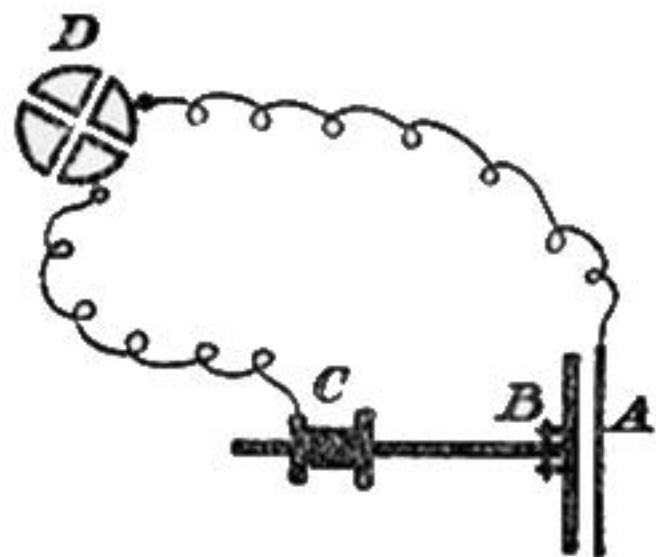
VI. "The Effect of Röntgen's Rays on Cloudy Condensation."

By C. T. R. WILSON, B.Sc. (Vict.), B.A. (Cantab.), Clerk-Maxwell Student. Communicated by Professor J. J. THOMSON, F.R.S. Received March 3, 1896.

In a paper on "The Formation of Cloud in the Absence of Dust," read before the Cambridge Philosophical Society, May 13th, 1895, I showed that cloudy condensation takes place in the absence of dust when saturated air suffers sudden expansion exceeding a certain critical amount.

I find that air exposed to the action of Röntgen's rays requires to be expanded just as much as ordinary air in order that condensation may take place, but these rays have the effect of greatly increasing the number of drops formed when the expansion is beyond that necessary to produce condensation.

Under ordinary conditions, when the expansion exceeds the critical



- A. Tinfoil plate.
- B. Zinc plate, supported by a brass rod, which slides through the brass collar C.
- D. Quadrant electrometer.
- E. Vacuum tube.
- F. Negative electrode of tube.
- G. Induction coil.
- H, H. Wires connecting house battery to induction coil.
- J. Tinfoil screen—over the hole from which the rays issued—used in some experiments.
- K. Wooden box lined with sheet zinc.